Emerging Research on Transit Oriented Development (TOD) at QUT

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University of Queensland

QUT

Collaborative research

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Big picture: role of transport

- Environment
  - Global warming
  - CO_2 emissions
- Economy
  - Congestion
- Society
  - Social Capital
  - Health

- Policy interventions – mode switch (car ⟶ PT, Walk, Cycle)
  - Pull factors
    - Increase the attractiveness of PT (fast, frequent, low cost)
  - Push factors
    - Reduce the attractiveness of car (e.g. congestion charging)
  - Soft policy measures
    - Campaign, travel planning
  - Hard policy measures
    - Modification in infrastructure

TOD: hard measures & pull factors

TODs

- **TOD: a relatively recent neighbourhood design concept**
  - It was first introduced by Peter Calthorpe in the Next American Metropolis (1993)
- **TOD is characterised by:**
  - Moderate to high density: residential and/or employment
  - Diverse land use patterns
  - Well-connected street networks (e.g. grid as opposed to cul-de-sacs)
  - Good public transport accessibility

Milton, Brisbane


Dallas, USA

Similar concepts in the literature

- Traditional neighbourhood design,
- Neo-traditional neighbourhood design,
- Mixed-use urban centres,
- Pedestrian pockets, and
- Transit adjacent development (TAD)

foster compact development (Ryan and McNally, 1995)

- "Evil twin" of TODs (Halbur, 2007)

TADs

- Like TODs, TADs are also located within a 10-min walk around a transit stations/stops (Renne, 2009).
- However, unlike TODs, TADs possess (Duncan, 2011; Renne, 2009):
  - suburban street patterns (e.g. cul-de-sac),
  - low densities, and
  - segregated land uses.

Fremont BART station

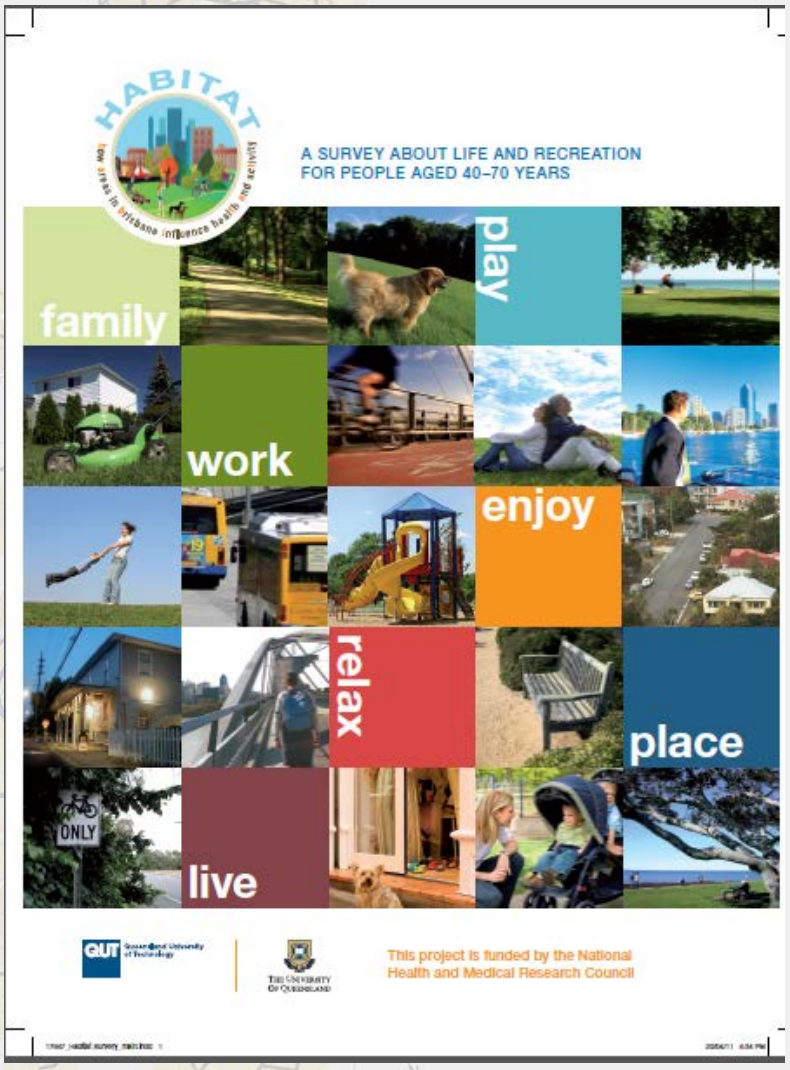
- Suburban development located adjacent to a train station cannot, therefore, be labelled as a TOD (Belzer and Autler, 2002).
- When TOD development goes bad, it often ends up with a TAD.
- TAD is being dealt for years and is often passed off as TOD (Hollenhorst, 2007); thereby diluting TOD research (Halbur, 2007)

Content (research so far and beyond)

- Typology of TODs (including non-TODs)
- Travel behaviour (e.g. mode choice) in TODs vs. non-TODs
- Effects of self-selection and residential dissonance
- Role of attitudes and preferences
- Social impacts of living in TODs (e.g. social capital)
- Research planned ahead
  - Environmental impacts of TODs
  - TOD Typology and Taxonomy of urban form
  - Health impacts of TODs
  - Joint-choice modelling of residential mobility and travel behaviour in TODs

Empirical data

- HABITAT (How Areas in Brisbane Influence HealTh and AcTivity) panel survey data
- Clustered random sampling (200 CCDs (11%) in Brisbane).
- Three phases (2007, 2009 and 2011) included 11036, 7866, and 6901 adults respectively
- Sample: the baby boomers cohort (aged between 40 and 70 years)



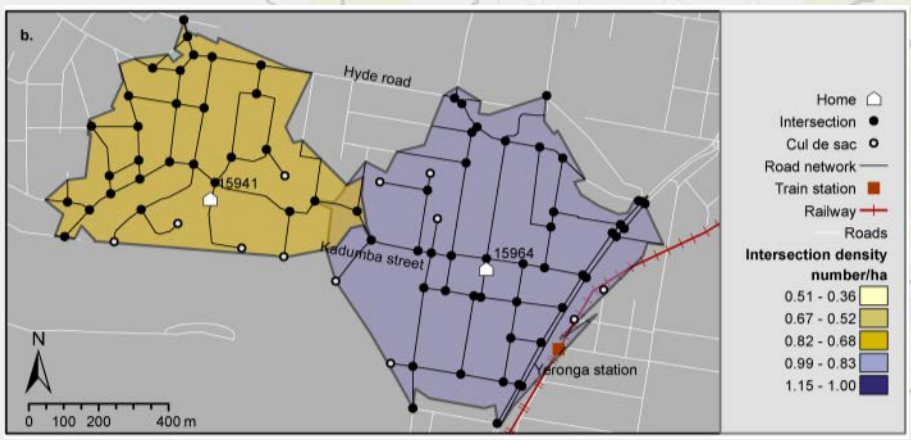
Controlling factors: Socio-demographics

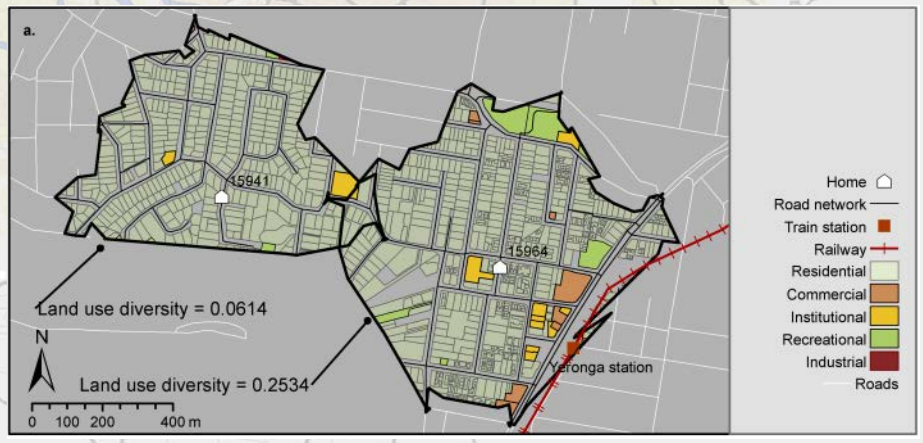
Socio-demographics	%	Socio-demographics	%	Average
Female	53.8	Living arrangement:		
Car availability		Living alone with no children	13.9	
Yes, always	92.5	Single parent with >=1 children	6.8	
Yes, sometimes	4.6	Single and living with friends	3.4	
No	1.5	Couple living with no children	28.1	
Do not drive	1.4	Couple living with >=1 children	46.3	
Employment status		Other	1.5	
Part time	32.2	Country of birth:		
Full-time	67.8	Australia	77.0	
Level of education		Other	23.0	
Up to year 12	31.0	Age		54.2
Diploma	29.0	Household size		2.9
Graduate and over	40.0	Health status		3.4
Income		Commute time		
1st quartile (lowest)	10.3	Less than 15 minutes	27.5	
2nd quartile	19.5	Commute time: 15-30 minutes	42.9	
3rd quartile	30.6	Commute time: 30-60 minutes	26.6	
4th quartile (highest)	27.2	Commute time: More than 60 minutes	3.0	
Missing	12.4			

Spatial data

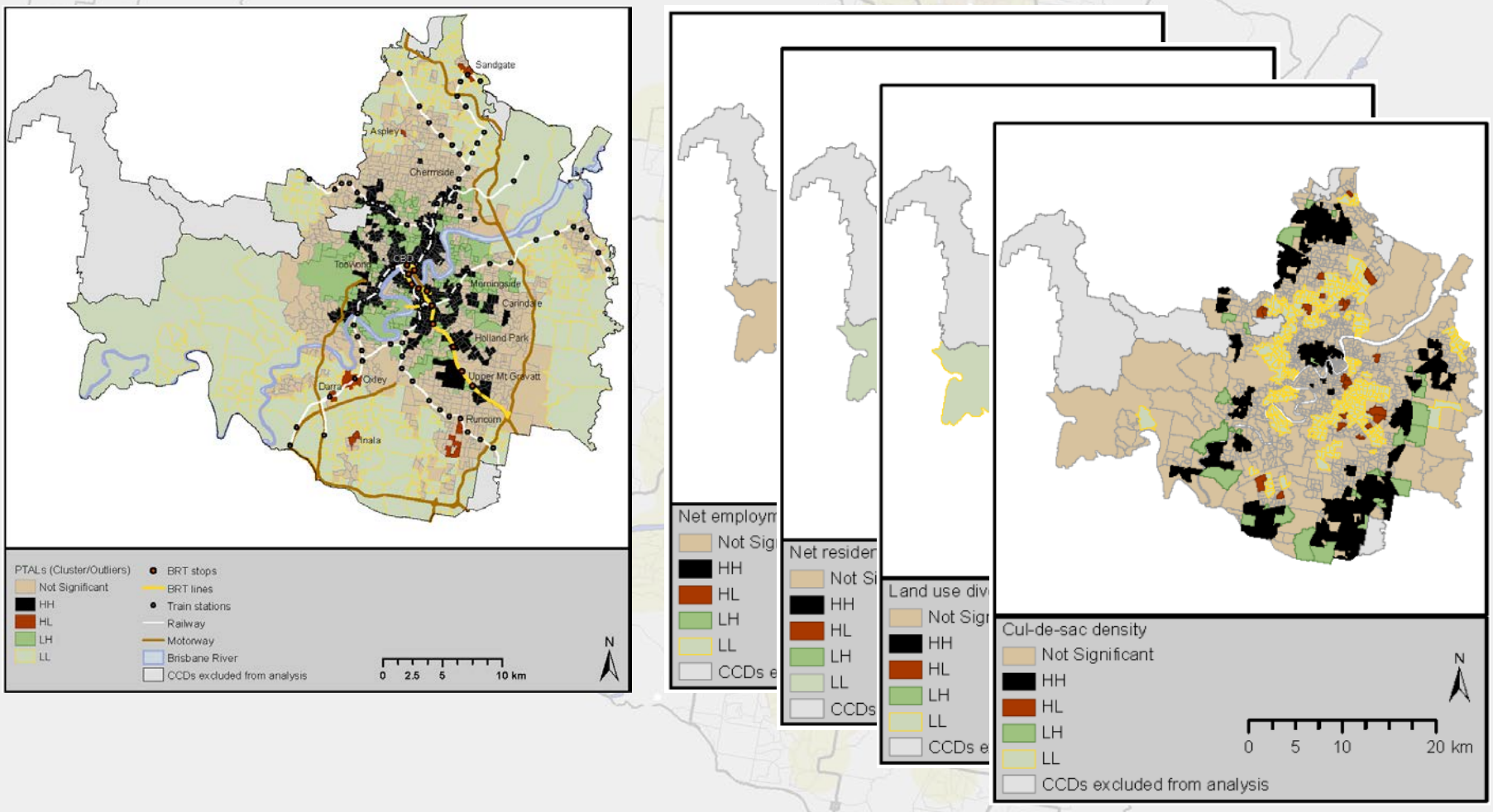
Derivation of built environment indicators

- **Six environmental factors were derived**
  (Kamruzzaman et al. 2013, 2014)
  - Public Transport Accessibility Levels (PTALs),
  - Net residential density,
  - Net employment density,
  - Land use diversity,
  - Intersection density, and
  - Cul-de-sac density.



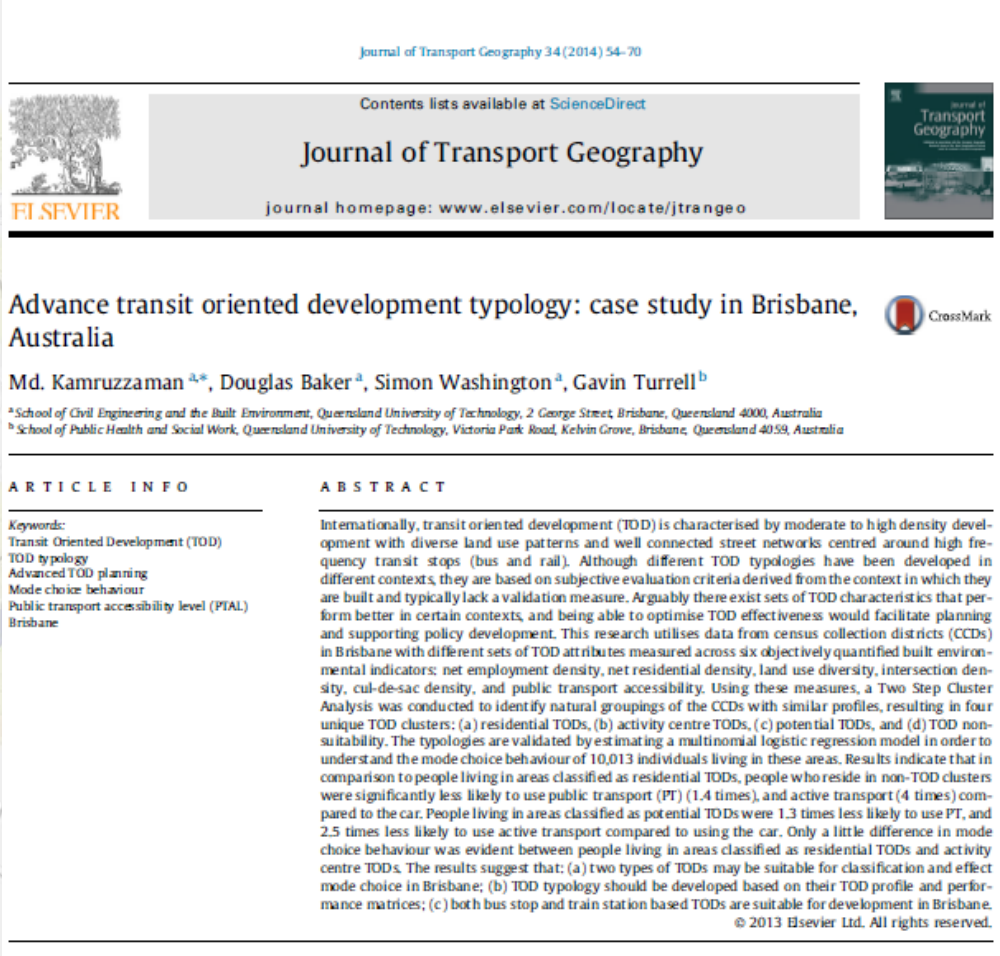


Spatial distribution of built environment indicators in Brisbane



TOD typology

- **Subjective classifications:**
  - city centre, activity centre,
  - specialist, urban, suburban,
  - neighbourhood, residential
  - commuter town centre (Calthorpe, 1993; Dittmar and Poticha, 2004; Queensland Government, 2009).
- **How do we guide to the design and building of TODs**
- **We argue that, we need:**
  - a careful selection of built environmental factors, and
  - their standards for different areas in a city



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Advance transit oriented development typology: case study in Brisbane, Australia

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ARTICLE INFO

Keywords:
Transit Oriented Development (TOD)
TOD typology
Advanced TOD planning
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Public transport accessibility level (PTAL)
Brisbane

ABSTRACT

Internationally, transit oriented development (TOD) is characterised by moderate to high density development with diverse land use patterns and well connected street networks centred around high frequency transit stops (bus and rail). Although different TOD typologies have been developed in different contexts, they are based on subjective evaluation criteria derived from the context in which they are built and typically lack a validation measure. Arguably there exist sets of TOD characteristics that perform better in certain contexts, and being able to optimise TOD effectiveness would facilitate planning and supporting policy development. This research utilises data from census collection districts (CCDs) in Brisbane with different sets of TOD attributes measured across six objectively quantified built environmental indicators: net employment density, net residential density, land use diversity, intersection density, cul-de-sac density, and public transport accessibility. Using these measures, a Two Step Cluster Analysis was conducted to identify natural groupings of the CCDs with similar profiles, resulting in four unique TOD clusters: (a) residential TODs, (b) activity centre TODs, (c) potential TODs, and (d) TOD non-suitability. The typologies are validated by estimating a multinomial logistic regression model in order to understand the mode choice behaviour of 10,013 individuals living in these areas. Results indicate that in comparison to people living in areas classified as residential TODs, people who reside in non-TOD clusters were significantly less likely to use public transport (PT) (1.4 times), and active transport (4 times) compared to the car. People living in areas classified as potential TODs were 1.3 times less likely to use PT, and 2.5 times less likely to use active transport compared to using the car. Only a little difference in mode choice behaviour was evident between people living in areas classified as residential TODs and activity centre TODs. The results suggest that: (a) two types of TODs may be suitable for classification and effect mode choice in Brisbane; (b) TOD typology should be developed based on their TOD profile and performance matrices; (c) both bus stop and train station based TODs are suitable for development in Brisbane.

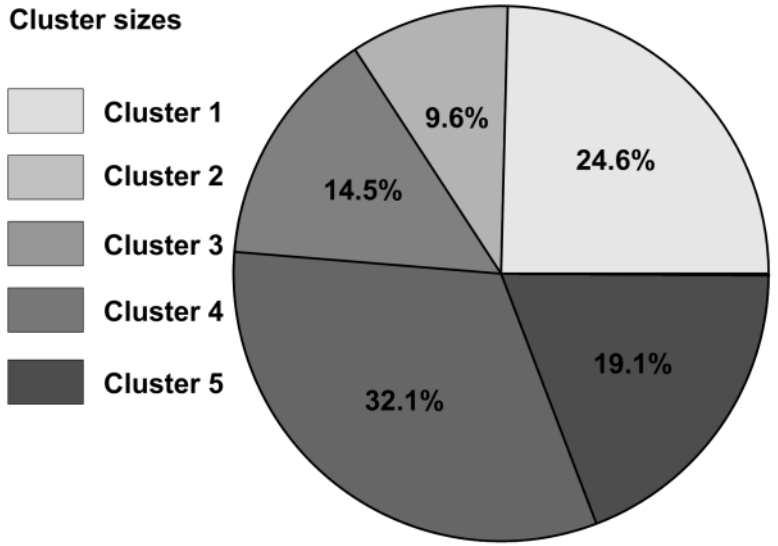
Identification of neighbourhood types: first stage cluster analysis

Model summary

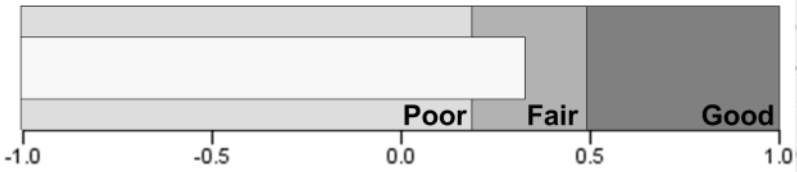
Algorithm	TwoStep
Inputs	6
Clusters	5

Size of smallest cluster	340 (9.6%)
Size of largest cluster	1137 (32.1%)
Ratio of sizes: largest to smallest cluster	3.34

Cluster sizes



Cluster quality



Silhouette measure of cohesion and separation

First stage cluster analysis

Input (predictor) importance

1.0 0.8 0.6 0.4 0.2 0.0

Cluster	1	2	3	4	5
Label	Non-TOD	Non-TOD	Activity Centre TOD	Potential Suburban TOD	Urban TOD
Size	24.6% (871)	9.6% (340)	14.5% (513)	32.1% (1137)	19.1% (676)
Inputs	CulDenOut 0.27	CulDenOut 0.19	CulDenOut 0.16	CulDenOut 0.09	CulDenOut 0.11
	EmpDenOut 4.84	EmpDenOut 7.48	EmpDenOut 83.20	EmpDenOut 13.60	EmpDenOut 64.98
	IntDenOut 0.60	IntDenOut 0.34	IntDenOut 0.54	IntDenOut 0.63	IntDenOut 0.71
	NtResDenOut 13.00	NtResDenOut 7.15	NtResDenOut 13.50	NtResDenOut 15.18	NtResDenOut 23.74
	ptal800Out 2.28	ptal800Out 0.75	ptal800Out 2.82	ptal800Out 3.58	ptal800Out 5.67
	DiversityOut 0.38	DiversityOut 0.20	DiversityOut 0.48	DiversityOut 0.46	DiversityOut 0.48

Identification of neighbourhood types: second stage cluster analysis

Model summary

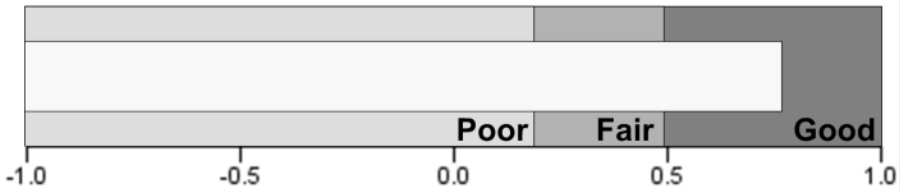
Algorithm	TwoStep
Inputs	1
Clusters	2

Size of smallest cluster	514 (42.4%)
Size of largest cluster	697 (57.6%)
Ratio of sizes: largest to smallest cluster	1.36

Input (predictor) importance

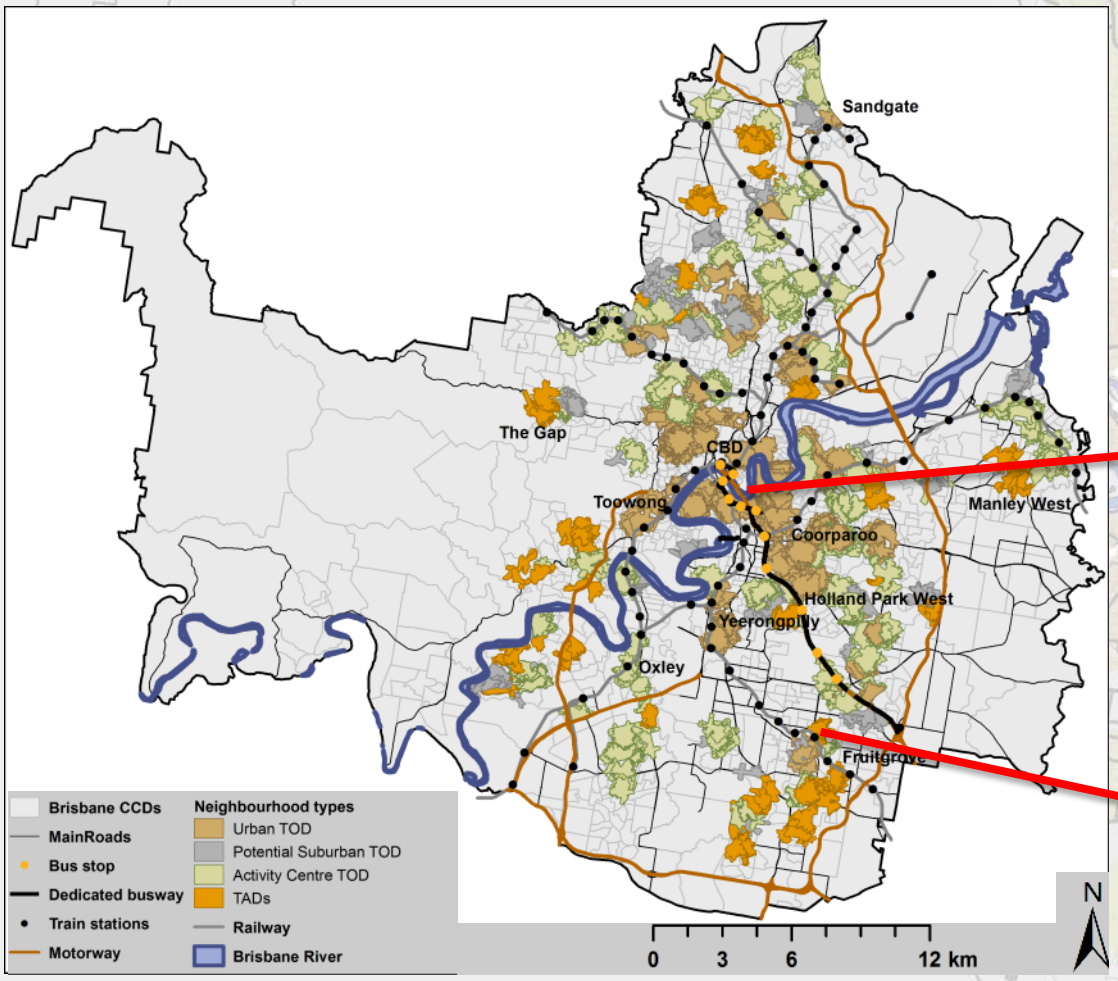
Cluster	1	2
Label	Non-TOD	TAD
Size	57.6% (697)	42.4% (514)
Inputs	ptal800Out 0.72	ptal800Out 3.38

Cluster quality



Silhouette measure of cohesion and separation

TOD typologies in Brisbane



Woolloongabba, Brisbane

Runcorn, Brisbane

Validation of the clusters

3.2 On most weekdays (Monday to Friday), which type of transport do you MAINLY use to get to and from places?

Please tick the main one.	Public transport	Car or motorcycle	Walk	Bicycle	Other
	☐	☐	☐	☐	☐

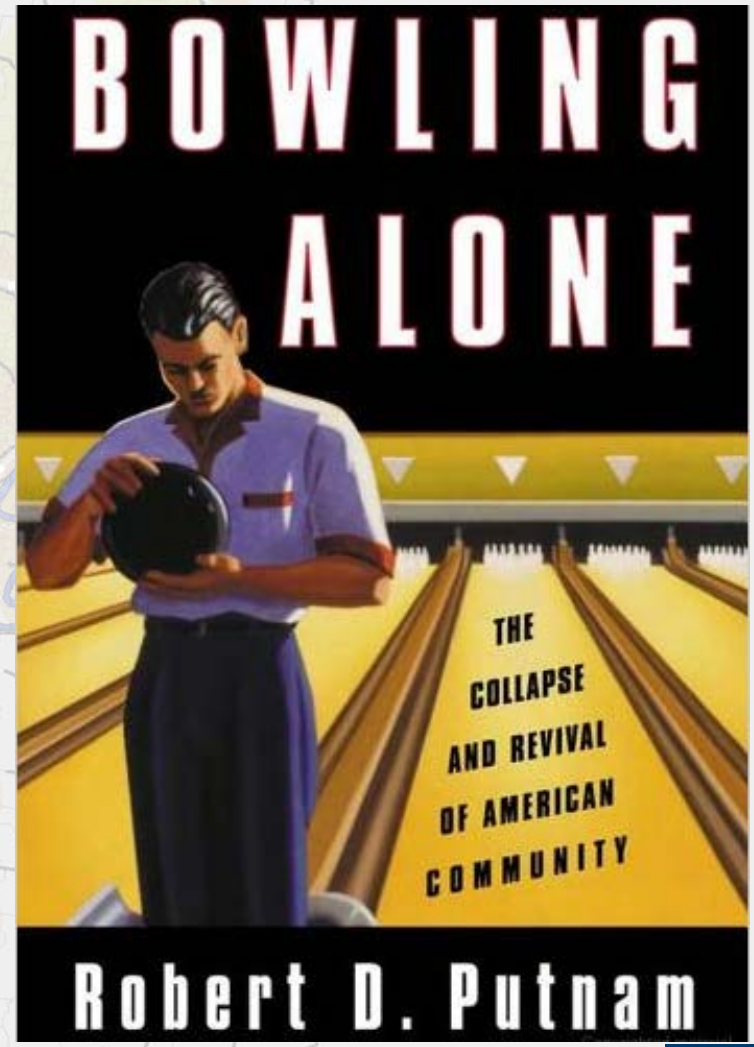
Explanatory factors	Main mode of transport used (ref: car)								
	Public Transport			Active Transport			Other		
	RRR[a]	z	p>|z|	RRR	z	p>|z|	RRR	z	p>|z|
Neighbourhood type (ref: Cluster 4 – Residential TOD)									
Cluster 1 (Non-TOD)	0.72	-2.08	0.04	0.26	-5.91	0.00	0.67	-0.77	0.44
Cluster 2 (Activity Centre TOD)	0.70	-1.71	0.09	1.12	0.39	0.70	0.94	-0.10	0.92
Cluster 3 (Potential TOD)	0.76	-1.72	0.09	0.40	-4.34	0.00	0.70	-0.72	0.47
Reasons for choosing neighbourhood									
Accessibility and mobility of places	2.66	15.55	0.00	1.97	7.31	0.00	1.04	0.17	0.87
Natural environment	0.85	-3.41	0.00	0.99	-0.19	0.85	0.86	-0.91	0.36
Child centric facilities	0.78	-4.10	0.00	0.88	-1.45	0.15	1.01	0.05	0.96
Ease of commuting	0.74	-5.50	0.00	0.73	-3.27	0.00	1.47	1.81	0.07
Socio-demographics.....									
Pseudo R2									0.19
N (2007 version of the survey)									10013

What is the value of typology research

- TODs have different meanings in different parts of the city
- The development of TOD needs to be contextually driven
- A more refined operational definition of TOD needs to be developed
- A taxonomical approach for urban design should accompany the typology

TODs and social capital

- Putnam (2000) found negative links between car dependence and the development of effective social capital.
- Hypothetically, TOD can influence the development of social capital
  - Participation in local activities enhances interaction and in turn increase the opportunity to be familiar and trust each other (Lund, 2002; Wood et al., 2008)
  - Similarly, travel by PT facilitates interactions and connections (Currie and Stanley, 2008)
- However, empirical evidence is comparatively sparse (Melia et al., 2011).



TODs and social capital

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Patterns of social capital associated with transit oriented development

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Transit oriented development
Transit adjacent development
Public transport accessibility level (PTAL)
Social capital
Social sustainability
Brisbane

ABSTRACT

In policy circles, transit oriented development (TOD) is believed to enhance social capital, however empirical evidence of this relationship is lacking. This research compares levels of social capital between TOD vs. non-TOD areas in Brisbane, Australia. Using a Two Step cluster analysis technique, three types of neighbourhood groupings were identified based on net employment density, net residential density, land use diversity, intersection density, and public transport accessibility: TODs, transit adjacent development (TADs) and traditional suburbs. Two dimensions of social capital were measured (trust and reciprocity, connections with neighbours) based on factor analysis of eight items representing elements of social capital. Multivariate regression analyses were conducted to identify links between the distributions of the dimensions of social capital on areas defined as TODs, TADs, and traditional suburbs controlling for socio-demographics and environmental factors. Results show that individuals living in TODs had a significantly higher level of trust and reciprocity and connections with neighbours compared with residents of TADs. It appears that TODs may foster the development of social sustainability.

Questionnaire statements/items representing elements of social capital

1.2 The following statements are about your suburb and the people living around you. How much do you agree or disagree with each statement?

Please tick the box that best applies to you and your suburb.	Strongly disagree	Disagree	Unsure	Agree	Strongly agree
I have a lot in common with many people in my suburb	☐	☐	☐	☐	☐
If I no longer lived here, hardly anyone around here would notice	☐	☐	☐	☐	☐
I am good friends with many people in my suburb	☐	☐	☐	☐	☐
I generally trust my neighbours to look out for my property	☐	☐	☐	☐	☐
I have little to do with most people in my suburb	☐	☐	☐	☐	☐
Most of the time, people in my suburb try to be helpful	☐	☐	☐	☐	☐
Generally speaking, people in my suburb can be trusted	☐	☐	☐	☐	☐
Most of the time, people in my suburb just look out for themselves	☐	☐	☐	☐	☐

Factor analysis to reduce dimensionality of data

Items	Scales (factors)	
	Connectedness with neighbours	Trust and reciprocity
I have much to do with most people in my suburb	0.878	-0.048
I am good friends with many people in my suburb	0.850	-0.002
If I no longer lived here, almost everyone around here would notice	0.743	0.036
I have a lot in common with many people in my suburb	0.471	0.274
Generally speaking, people in my suburb can be trusted	-0.126	0.908
Most of the time, people in my suburb try to be helpful	0.084	0.804
I generally trust my neighbours to look out for my property	0.187	0.515
Rarely, people in my suburb just look out for themselves	0.335	0.502
Sum of squared loadings (rotated)	3.906	3.716
% of variance explained	54.881	7.211
Factor extraction method: Principle Axis Factoring		
Rotation method: Oblimin Quartimin with Kaiser normalisation		
Correlation matrix: Polychoric		
N (2011 version of the survey)		5606

Results: multivariate multiple regression

Explanatory factors	Dependent variables: dimensions/scales of social capital			
	Connectedness with neighbours		Trust and reciprocity	
	Coef.	t	Coef.	t
Neighbourhood classification: (ref: TAD)				
TOD	0.62	3.35	0.33	2.42
Traditional suburbs	0.40	3.47	0.29	3.51
PTALs (continuous)	-0.03	-1.89	-0.02	-1.24
Net residential density (continuous)	-0.01	-2.22	-0.01	-3.44
Length of stay (years) (continuous)	0.02	4.94	0.00	0.49
Socio-demographics.....				
Constant	11.39	53.44	14.13	90.15
F		14.52		10.34
R^2		0.04		0.03
Wilks' lambda (F)				7.76
Lawley–Hotelling trace (F)				7.77
Pillai's trace (F)				7.75
Roy's largest root (F)				10.19
N				5606

What about residential self-selection effect?

- The relationships between the built environment (e.g. TOD) and travel behaviour are spurious/accidental
- This is particularly due to the failure of incorporating right variables including residential self-selection effect.
- Two sources of residential self-selection effects included:
  - Socio-demographics (these have been considered in almost all studies)
    - e.g. non-car owning choose TOD because they don't have car, not because of TOD
  - Travel attitudes and residential preferences (difficult to observe directly)
    - e.g. individuals with positive perception about PT may choose to live in TOD
- TODs do not influence the use of PT in this case but it merely facilitates the use

What if you live in a neighbourhood that you don't like/prefer?

- In the context of an urban area:
  - You are more likely:
    - to use the car
    - travel longer distances
- In the context of a non-urban/rural area:
  - You are less likely:
    - to use the car
    - travel shorter distances

(Schwanen and Mokhtarian, 2005a; 2005b; De Vos et al., 2012)

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Residential dissonance and mode choice

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ARTICLE INFO

Keywords:
Residential dissonance
Transit oriented development
Travel behaviour change
Residential self-selection

ABSTRACT

Residential dissonance refers to the mismatch in land-use patterns between individuals' preferred residential neighbourhood type and the type of neighbourhood in which they currently reside. Current knowledge regarding the impact of residential dissonance is limited to short-term travel behaviours in urban vs. suburban, and rural vs. urban areas. Although the prevailing view is that dissonants adjust their orientation and lifestyle around their surrounding land use over time, empirical evidence is lacking to support this proposition. This research identifies both short-term mode choice behaviour and medium-term mode shift behaviour of dissonants in transit oriented development (TODs) vs. non-TOD areas in Brisbane, Australia. Natural groupings of neighbourhood profiles (e.g. residential density, land use diversity, intersection density, cul-de-sac density, and public transport accessibility levels) of 3957 individuals were identified as living either in a TOD (510 individuals) or non-TOD (3447 individuals) areas in Brisbane using the TwoStep cluster analysis technique. Levels of dissonance were measured based on a factor analysis of 16 items representing the travel attitudes/preferences of individuals. Two multinomial logistic (MNL) regression models were estimated to understand mode choice behaviour of (1) TOD dissonants, and (2) non-TOD dissonants in 2009, controlling for socio-demographics and environmental characteristics. Two additional MNL regression models were estimated to investigate mode shift behaviour of (3) TOD dissonants, and (4) non-TOD dissonants between 2009 and 2011, also controlling for socio-demographic, changes in socio-demographic, and built environmental factors. The findings suggest that travel preference is relatively more influential in transport mode choice decisions compared with built environment features. Little behavioural evidence was found to support the adjustment of a dissonant orientation toward a particular land use feature and mode accessibility they represent (e.g. a modal shift to greater use of the car for non-TOD dissonants). TOD policies should focus on reducing the level of dissonance in TODs in order to enhance transit ridership.

Residential Dissonance

- An individual's satisfaction as to where they live
- The mismatch between an individual's preferred neighbourhood type and where they reside
- Dissonance affects travel behaviour

Residential dissonance in the context of TODs

Multinomial logistic regression analyses results showing mode choice behaviour in TOD and non-TOD areas in Brisbane in 2009.[a]

Explanatory factors ('09)	Model 1: Mode choice behaviour in TODs in 2009 (ref: car/motorcycle)					
	PT			AT		
	OR (B)	95% C.I. for ORs		OR (B)	95% C.I. for ORs	
Intercept	(1.53)			(−1.86)		
Level of dissonance (for TOD areas)	0.34 (−1.08)	0.22	0.51	0.58 (−0.55)	0.38	0.88
Level of consonance (for non-TOD areas)	NA	NA	NA	NA	NA	NA
Intersection density						
Cul de sac density						
Net residential density						
Public transport accessibility level (PTAL)	0.96 (−0.46)	0.81	1.13	1.43 (0.35)	1.16	1.75
Female (ref: male)						

Multinomial logistic regression analyses results showing mode switch behaviour in TOD and non-TOD areas in Brisbane between 2009 and

Explanatory factors	Model 3: Mode shift behaviour in TODs (ref: unchanged)								
	Changed to car			Changed to PT			Changed to AT		
	OR (B)	95% C.I. for ORs		OR (B)	95% C.I. for ORs		OR (B)	95% C.I. for ORs	
Intercept	(0.70)			(5.34)			(0.46)		
Base variables ('09)									
Level of dissonance (for TOD areas)	0.59 (−0.53)	0.34	1.02	0.51 (−0.68)	0.26	0.97	0.61 (−0.49)	0.29	1.31
Change variables (09–11)									
Changes in the level of dissonance (TOD areas)	1.05 (0.05)	0.54	2.02	0.56 (−0.58)	0.25	1.25	0.28 (−1.29)	0.11	0.72

Do dissonants adjust commute behaviour

- **No, at least in the short-mid term period**

Do Residential Dissonants Adjust Commuting Travel Behaviour?
KAMRUZZAMAN, Md; BAKER, Douglas; TURRELL, Gavin

13th WCTR, July 15-18, 2013 – Rio de Janeiro, Brazil

DO DISSONANTS IN TRANSIT ORIENTED DEVELOPMENT ADJUST COMMUTING TRAVEL BEHAVIOUR?

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ABSTRACT

Current knowledge regarding the impact of residential dissonance is limited to short-term travel behaviours in urban vs. suburban and rural vs. urban areas. This current research identifies both short- and medium-term commuting mode choice behaviour impacts of residential dissonance in Transit Oriented Developments (TODs) vs. non-TODs in Brisbane, Australia. Based on the characteristics of living environments (e.g. density, diversity, connectivity, and accessibility) and the travel preferences of 2816 individuals, respondents were classified into one of four categories including TOD consonants, TOD dissonants, non-TOD dissonants, and non-TOD consonants. Binary logistic regression analyses were employed to identify mode choice behaviour of groups in 2009 and 2011, controlling for socio-demographic effects. The findings suggest that travel preference is relatively more influential in transport mode decisions compared to built environment factors; however, the

Do dissonants move residence to their preferred neighbourhood?

- No, apartments in TODs are an investment in Brisbane

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Does Residential Dissonance Affect Residential Mobility?

M. Kamruzzaman, Simon Washington, Douglas Baker, and Gavin Turrell

This research identifies the impacts of residential dissonance on residential mobility behavior in transit-oriented developments (TODs) versus non-TODs in Brisbane, Australia. On the basis of the characteristics of living environments (density, diversity, connectivity, and accessibility) and the travel preferences of 4,545 individuals, respondents in 2009 were classified into one of four categories: TOD consonants, TOD dissonants, non-TOD dissonants, and non-TOD consonants. Binary logistic regression analyses were employed to identify residential mobility behavior of groups between 2009 and 2011 while controlling for time-varying covariates. The findings show that both TOD dissonants and TOD consonants move residences at an equal rate. However, TOD dissonants are more likely to move residences to their preferred non-TOD areas. In contrast, non-TOD dissonants not only move residences at a lower rate, but their rate of mobility to their preferred TOD neighborhood is also significantly lower because of costs and other associated factors. The findings suggest that development of policies for discrete land use is required to integrate non-TOD dissonant and TOD dissonant behaviors to support TOD development in Brisbane.

dissonants make longer-distance trips on a
nants. Much of this research bears signific
a neighborhood design concept that relie
dential densities, mixed land uses, high le
and close proximity to public transport. T
land use policy worldwide to reduce carb
tion and to improve physical health (*5*).
prior research findings, if TOD dissonants
TOD areas as a result of other incentives
choice, proximity to work) or if TODs are
ing residents who become dissonant, reali
objectives will be challenged by their beha
fully achieve its desired effect.

Schwanen and Mokhtarian hypothesized
may be ameliorated through adjustment o
or attitude toward land use or, eventually
time (*2*). In relation to the first hypothesis
offered to support the adaptation of disson
land use features (e.g., TOD). In another

Do dissonants move residence to their preferred neighbourhood?

TABLE 4 Binary Logistic Regression Analysis Results: Residential Mobility Patterns of Different Groups

	Model 1: Movers versus Non-Movers			Model 2: Moved from TOD			Model 3: Moved from Non-TOD		
	Mover (ref: nonmover)			Moved into non-TOD (ref: moved into TOD)			Moved into TOD (ref: moved into non-TOD)		
Factor	OR		95% CI	OR		95% CI	OR		95% CI
TOD dissonants (ref: TOD consonants)	—	—	—	2.373[a]	1.281	4.396	na	na	na
Non-TOD consonants (ref: TOD consonants)	—	—	—	na	na	na	na	na	na
Non-TOD dissonants (ref: TOD consonants)	0.771[b]	0.588	1.010	na	na	na	na	na	na
Non-TOD dissonants (ref: non-TOD consonants)	na	na	na	na	na	na	0.465[a]	0.220	0.983
Residential density	—	—	—	—	—	—	0.998[a]	0.997	1.000
Land use diversity	—	—	—	—	—	—	87.53[a]	2.095	3,657.793
PT accessible (ref: PT inaccessible)	0.754[b]	0.552	1.031	—	—	—	4.094[a]	1.420	11.803
Length of stay	0.933[a]	0.915	0.951	—	—	—	—	—	—

So what does this mean?

- Dissonants affect the effectiveness of TOD policy
- Automobile use continues - and congests TOD areas
- Opportunities for other users (consonants) are constrained
- A stronger combination of hard/soft measures & push/pull factors will be required to manage TOD

Conclusion

- Our research confirms the independent effects of TODs on promoting sustainable travel behaviour
- Residents living in urban TODs are more likely to use the PT services and less likely to use the car
- Residents in TODs also have a higher level of social capital
- Attitudes and preferences are much stronger predictor of travel behaviour than the built environment (e.g. TOD)
- Dissonants exhibit unsustainable travel behaviour
- Dissonants do not change their behaviour, nor they move residences – TOD policy is threatened
- How do we change attitudes and preferences – a billion dollar question

Conclusion

- Comprehensive analysis:
  - True impact of TODs on mode choice
- TADs are the “evil twin” of TOD
- TADs can be converted into a TOD with relative ease in order for full benefits to be realised.

Conversion from TAD to TOD, Subiaco WA